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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Outlines test procedures and methods for use in evaluating the performance of tropo-scatter communications systems. Includes checklist and data collection sheets.

US ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

DRSTE-RP-702-105 3 June 1981
*Test Operations Procedure 6-2-315
AD No. A100416

TROPO-SCATTER COMMUNICATIONS SYSTEMS

1. SCOPE

These procedures outline the particular tests and test methods for use in evaluating the performance and characteristics of tropo-scatter communications systems. They serve as a guide in determining the overall efficiency of such equipments as a function of design and the recorded test performance. Notwithstanding the accuracies, frequencies, and levels stated in this test operations procedure (TOP), the specific equipment requirements stated in the appropriate requirements document must be used.

1.1 Specific Subtests:

1.1.1 Transmission Tests: The objective of the subtest is to determine performance by measuring the received signal level as a function of:

a. Propagation mode.

b. Diversity techniques.

c. Time.

d. Meteorological conditions.

e. The geometric parameters of the radio path.

1.1.2 Compatibility Tests: The objective of the subtest is to determine the adequacy of the tropo-scatter communications equipment as a system from terminal to terminal, e.g., from transmitter to receiver using associated peripheral equipment.

*This TOP supersedes MTP 6-2-315, 11 July 1969.

1.2 Limitations:

1.2.1 Transmission Tests:

a. This subtest considers the tropo-scatter transmitter and receiver, and associated repeater stations, as a complete system. It does not consider the peripheral equipments that may be used with the system, e.g., fascimile, teletype, encryption/decryption, multiplexer devices.

b. In assessing the communications reliability of the tropo-scatter path, a low degree of prediction certainty is associated with the subtest because of the time constraints during test conduct.

1.3 Exclusions: Several specific tests that are generally applied for the evaluation of tropo-scatter communications systems are omitted in this TOP because they are replicated in other TOPs and/or military standards. When a need arises to include such testing in the test plan, the following tests with appropriate references may be used:

a. Electrical Power Requirements: TOP 6-2-514.

b. Frequency, Accuracy and Stability: TOP 6-2-517.

c. Spurious Emission and Response: TOP 6-2-545 and MIL-STD-449D.

d. Electromagnetic Vulnerability: TOP 6-2-508.

e. Electromagnetic Compatibility: MIL-STD-461B.

f. Antenna Radiation Patterns: TOP 6-2-020.

g. Antenna Gain: TOP 6-2-020.

h. Antenna Polarization: TOP 6-2-020.

i. Power Output: TOP 6-2-242.

j. Modulation Characteristics: TOP 6-2-242.

k. Carrier Noise Level: TOP 6-2-242.

l. Receiver Selectivity: TOP 6-2-242.

m. Audio Frequency Response: TOP 6-2-242.

n. Radio Receiver Sensitivity (Non-pulsed): TOP 6-2-5[illegible].

2. FACILITIES AND INSTRUMENTATION

2.1 Facilities:

ITEM	REQUIREMENT
Communications Test Facility	Used to simulate tactical configurations and environments in which the tropo-scatter system is designed to function.
Mobile Data Acquisition Facility	Used to monitor performance of the test system.
Meteorological Support Facility	
Tactical/Administrative Vehicle Support	

2.2 Instrumentation:

2.2.1 Instrumentation requirements depend on equipment design. While developing the test plan, the test officer is responsible for selecting instrumentation that will satisfy the following requirements and standards:

a. The accuracy and stability of the measuring instrument shall exceed the accuracy and stability of the test item by at least one order of magnitude.

b. Measurement apparatus will bear current calibration tags. Upcoming calibration dates must be adequate for the duration of testing.

2.2.2 The test officer should consider the following instrumentation and equipment for the data collection effort:

ITEM	CHARACTERISTICS/ACCURACY (OR AS APPROPRIATE)
Voltmeter-Field Intensity Meter	Frequency Range: 1.5 to 400 MHz Sensitivity: 0.5 Microvolts Selectivity: 2.1 KHz at -6 dB
Radiosonde	
Time Totalizer Recorder	
Transit	

3. PREPARATION FOR TEST

3.1 Planning: The test officer must assure himself that the test plan will sufficiently exercise the test item to accomplish the reasons for undertaking the test. For development tests (DT), the Independent Evaluation Plan (IEP) and the Test Design Plan (TDP) will usually outline the particular requirements to be included in the test plan. The assigned test project officer will activate a project notebook for each test item, recording in it pertinent descriptive and technical information. The project notebook provides a narrative discussion of test results and is kept current for the duration of the test program. In addition, test planning encompasses a consideration of the potential foreign threat factors that will permit a realistic evaluation of the test system in a threat environment. Complete test planning requires that the test officer:

a. Prepare a test operations checklist using appendix A as a guide.

b. Incorporate complete safety aspects within the preparations for the test.

c. Brief test personnel on all aspects of the test program to include the purpose of the test and the precision requirements during test conduct.

d. Provide sufficient copies of operating instructions to all test personnel.

3.2 Facilities: Preparation of the test facilities for use in conducting tropo-scatter communications systems testing should consider the following:

a. Availability of adequate lead time when scheduling test facilities to be involved in the test program.

b. Preparation of laboratory benches and floor space.

c. Assembly of the necessary tools, operating instructions, loads, and equipment handling devices.

3.3 Test Item: In his preparations for test conduct, the test officer will insure that:

a. A record of the test item nomenclature, its technical characteristics, its manufacturer, and its performance parameters are entered into the project notebook.

b. The test item is photographed from several perspectives to provide a nonambiguous visual identification and description of the test item.

c. The test item and all of its associated components are inspected for damage, deterioration, and obvious manufacturing defects.

d. The test item is in proper operating condition.

3.4 Instrumentation: In his preparations for test conduct, the test officer will insure that:

a. All test equipment and other instrumentation are scheduled and readily available for use during test conduct.

b. All test equipment is calibrated prior to the scheduled test start date and that calibration standards equal or exceed the standards stipulated in paragraph 2.2.1 above.

c. The signal generators used during testing have a source impedance equal to the impedance of the receiver-transmitter unit under test.

4. TEST CONTROLS

4.1 Facilities: Line voltages used to power both the test item and the instrumentation should not vary more than five per cent from the mean.

4.2 Test Item:

a. The tuning procedures used for all test items will follow the instructions prescribed in an appropriate technical manual or manufacturer's operational instructions.

b. Except as directed by test procedures, the test item will not be moved, adjusted, or calibrated while comparative and reproducibility tests are in progress.

c. Antennas and dummy loads will be consistent throughout the conduct of comparative and reproducibility testing.

4.3 Instrumentation:

a. Applicable instrumentation will satisfy the standards for accuracy and stability as outlined in paragraph 2.2.1 above.

b. Instrumentation will be calibrated prior to test conduct.

c. The same instrumentation will be used throughout a particular subtest.

4.4 End Instruments: Although this procedure does not specifically consider peripheral equipments (see paragraph 1.2.1a above), there is a requirement to assess the performance of end instruments associated with a particular configuration of the test item. These procedures are delineated under paragraph 5.1.2 below.

5. PERFORMANCE TESTS

5.1 Method:

5.1.1 Transmission Tests: Transmission tests are performed to insure that the test system transmits a true tropo-scatter signal. Care must be taken to insure that atmospheric conditions and local geography do not cause tropo-scatter emissions to appear at the receiving site as line-of-sight (LOS) microwave signals. Such signals occur during operational conditions but are transient in nature and would therefore not provide an accurate indication of the tropo-scatter system performance. A tropo-scatter link is generally greater than 70 miles and sites may be several hundred miles distant - well beyond the range of the typical LOS link. The receive level of the true tropo-scatter signal is constantly changing in its intensity level which produces a characteristic swishing background noise. LOS transmissions, on the other hand, are characterized by a relatively constant level of signal intensity. Atmospheric phenomena, such as ducting, a situation in which the signal is trapped between two layers of the atmosphere for a considerable distance, can cause a LOS signal to appear at the receiving site and be mistaken as the tropo-scatter signal. Similarly, terrain features can often cause the reflection of LOS signals over distances that would not normally be typical of LOS transmission. Knife-edge diffraction is yet another phenomena of terrain features causing LOS signals to be received when an intervening natural barrier would otherwise block such transmissions. Care in the selection of test paths, the test sites, and the conduct of site surveys can minimize the chances of a LOS signal appearing at the receiving site and being mistaken for the true tropo-scatter signal. In the conduct of tropo-scatter transmission tests, the following steps are appropriate:

a. Select test paths and test sites that are representative of a typical tropo-scatter communications system link.

b. Draw the test paths and indicate the test sites on a topographical map.

c. Survey each test site using the following steps:

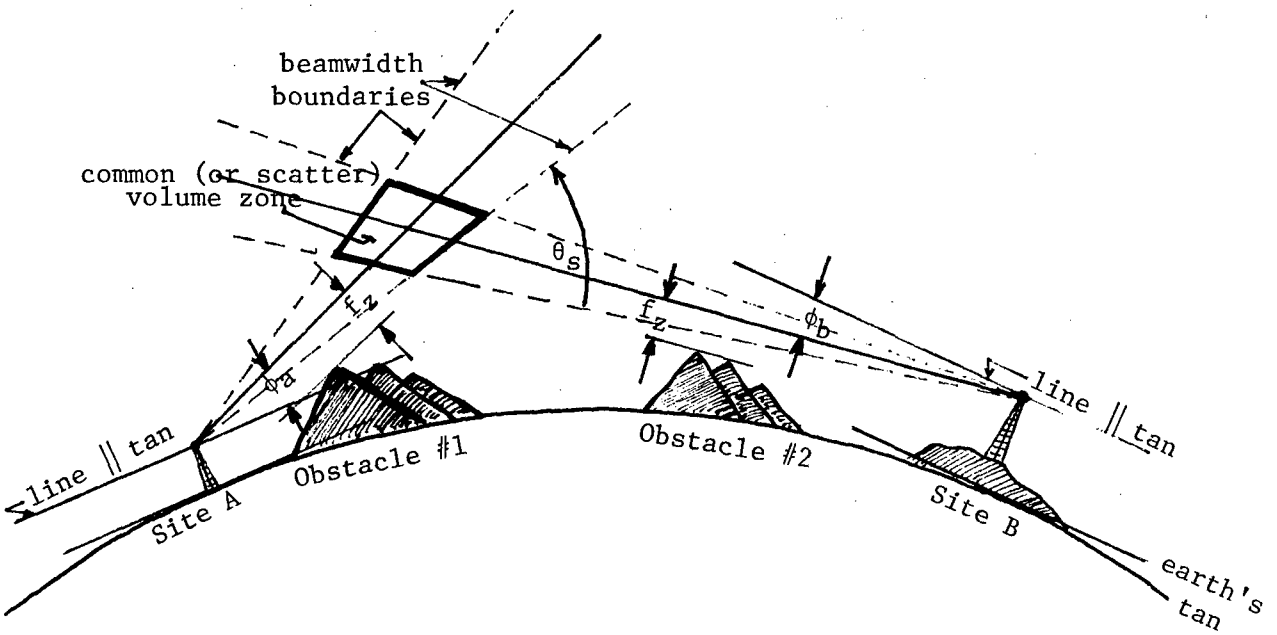
(1) Profile the test path between test sites using a profile chart, DA Form 4219.

(2) From the profile, develop a horizon angle[1] for each test site.

(3) From the profile, develop the scatter angle[2] and the location of the common (or scatter) volume.

1/ The horizon angle is defined as the angle formed by the center line of the antenna beam pattern and a line parallel to the earth's tangent at the base of the antenna (see ϕ_A and ϕ_B in figure 1).

2/ The scatter angle is defined as the angle formed by the lower boundaries of the transmitter and receiver beam patterns (see θ_s in figure 1).



ϕ_a = the positive horizon angle at Site A.

ϕ_b = the negative horizon angle at Site B.

f_z = standard 60-foot Fresnel zone clearance.

θ_s = scatter angle.

Note: Figure is not drawn to scale; all angles are exaggerated for presentation purposes.

Figure 1. Tropospheric Scatter System Relationships

(4) Aim the antenna beam as low as possible but high enough to clear the horizon point to include vegetation and a standard 60-foot Fresnel zone clearance (see figure 1).

(5) Record the azimuth for each selected test path.

(6) Indicate on a map the boundaries of each test path as lines ±10 degrees from the center line of the azimuth.

d. Record ambient noise levels at each test site before test start.

e. Insure that meteorological support functions include radiosonde observations in the vicinity of the transmitting and receiving sites, at the location under the common volume, and at least every 100-mile intervals along each transmission path. A sufficient number of observations are needed to insure that the impact of meteorological conditions can be properly assessed when evaluating the quality of tropo-scatter transmissions over a 24-hour period.

f. Establish a radio frequency (rf) link following the procedures outlined in an appropriate technical manual or manufacturer's operational instructions. Maintain the rf link on a 24-hour operational basis for a period of four days.

g. Tap the incoming rf signal before the first rf amplifier or at the first convenient point within the receiver section. Using a time totalizing recorder, record the incoming signal in the form of an analog DC voltage.

h. Repeat steps c through g for each test path used.

i. Repeat steps c through h for each equipment configuration used during testing.

5.1.2 Compatibility Testing: The particular steps enumerated under compatibility testing may be performed separately or in conjunction with the steps listed in paragraph 5.1.1 above:

a. Select test paths and test sites representative of a typical tropo-scatter communications system link.

b. Draw the test paths and indicate the test sites on a topographical map.

c. Survey the test sites as indicated in paragraph 5.1.1c above.

d. Record ambient noise levels at each test site before test start.

e. Insure adequate meteorological support as noted in paragraph 5.1.1d above.

f. Establish an rf link as noted in paragraph 5.1.1e above.

g. Use a time totalizing recorder to record the incoming rf signal in the form of an analog DC voltage.

h. Repeat steps c through g for each test path used.

i. Repeat steps c through h for each equipment configuration used during testing.

5.2 Data Required:

5.2.1 Transmission Tests:

a. Draw a block diagram of each equipment configuration used during testing.

b. Record the following test data for each test path:

(1) A topographic map clearly identifying each test site and the boundaries of each test path.

(2) A profile of each test path.

(3) Verification of the tropo-scatter mode of propagation.

(4) The elevation angle from each test site.

(5) Photographs of each test site.

(6) Meteorological data affecting the test sites and the test paths during test conduct (may be recorded on MF1 Form 10c, Surface Weather Observation).

(7) Ambient noise data at the test sites as indicated on a noise and field intensity meter at 30-meter intervals.

(8) The level of the received rf signal in -dBm on each receiver, at the same 30-minute intervals in (7) above.

5.2.2 Compatibility Tests:

a. Draw a block diagram of each equipment configuration, to include all end instruments, used during testing.

b. Record the data required under paragraph 5.2.1b above.

c. Record the end instrument performance during operations with the tropo-scatter communications system under test. Performance of a particular end instrument will be assessed against specified technical and operational criteria.

6. DATA REDUCTION AND PRESENTATION

6.1 Data Reduction:

6.1.1 Transmission Tests:

a. Determine the spacing of data point intervals by the degree of signal fade and the recorder time constant.

b. Select data points from the continuous recording at equally spaced intervals.

c. Calculate the hourly average level of the incoming rf signal using the data contained on the continuous recording.

6.1.2 Compatibility Tests:

a. In a manner similar to that outlined in paragraph 6.1.1 above, compute the hourly median mid-range level of the incoming rf signal.

b. Determine the suitability of the incoming rf signal for a particular type of transmission for each communications link and equipment configuration. The incoming signal is deemed suitable if the end instruments function in accordance with the specified technical and operational criteria for that end instrument.

6.2 Presentation:

6.2.1 Transmission Tests:

a. Present the median values of the incoming rf signal level graphical format as a function of time in a manner similar to that shown in appendix B, page B-2. Indicate the times of sunrise and sunset along the abscissa.

b. Present a distribution curve for each test path and equipment configuration in a manner similar to that shown in appendix B, page B-3.

c. Present a transmission path profile chart for each test path using DA Form 4219.

d. Present a topographical map of the test area indicating test sites and the boundaries of the test paths used.

e. Present meteorological data in a tabular format.

f. Present the received rf levels and the ambient rf noise levels in a tabular format in a manner similar to that shown in appendix B, page B-4.

6.2.2 Compatibility Tests: The presentation of data collected during compatibility testing is to be performed in a manner similar to that outlined in paragraph 6.2.1, above. Additionally, specific information concerning the performance of end instruments associated with the tropo-scatter system under test will be tabulated to reflect actual test performance in comparison with operational and technical specifications prescribed for the end instrument.

Recommended changes to this publication should be forwarded to Commander, U.S. Army Test and Evaluation Command, ATTN: DRSTE-AD-M, Aberdeen Proving Ground, MD 21005. Technical information may be obtained from Commander, U.S. Army Electronic Proving Ground, ATTN: STEEP-MT-T, Fort Huachuca, AZ 85613. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A

CHECKLIST FOR TROPO-SCATTER COMMUNICATIONS SYSTEMS TESTS

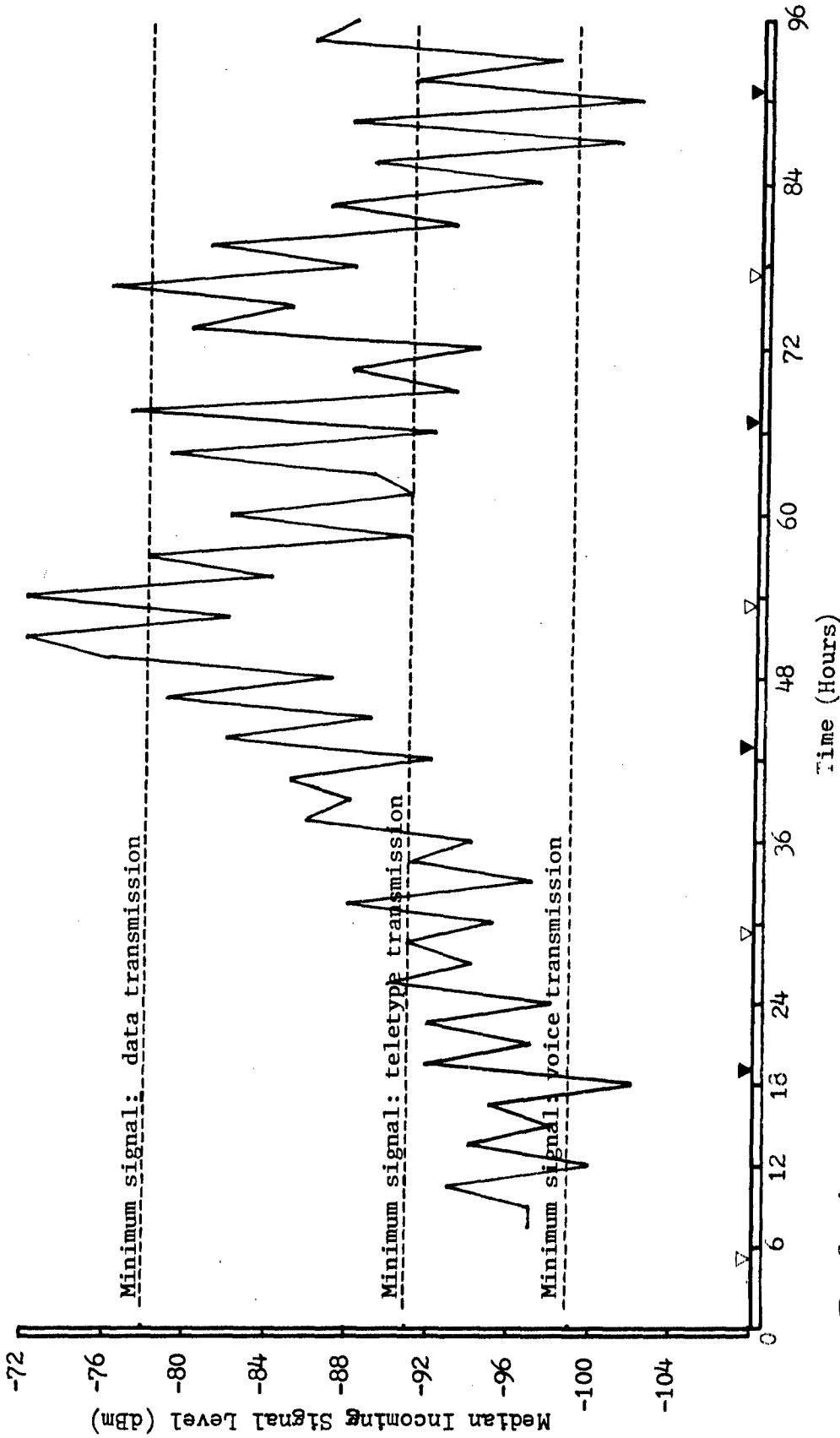
	INITIALS	
	Test Officer	Test Supervisor
Availability of appropriate documentation and authority for the conduct of the test program:	_____	_____
Initiate a project notebook:	_____	_____
Establish the project file:	_____	_____
Availability of appropriate references:	_____	_____
Required Operational Capability (ROC):	_____	_____
Test item specifications:	_____	_____
Military Standards:	_____	_____
Test Operations Procedures:	_____	_____
Operating Manuals:	_____	_____
Coordination with test sponsor/contractor:	_____	_____
Are dates for desired test execution realistic?	_____	_____
Availability of test plan to all participants:	_____	_____
Coordination for necessary test support:	_____	_____
Identification of critical test issues:	_____	_____
Test facility conforms to specified standards:	_____	_____
All test personnel briefed	_____	_____
Instrumentation data have been recorded:	_____	_____
Calibration due date for all instrumentation will permit completion of testing:	_____	_____
Test item data recorded in project notebook:	_____	_____
Reference level test tapes are on hand:	_____	_____
Initial inspection performed:	_____	_____
Photographs taken of test item(s):	_____	_____
Photographs taken of test sites:	_____	_____
Equipment performance reports prepared:	_____	_____
Data collection sheets are complete:	_____	_____
Test report prepared:	_____	_____

APPENDIX B

DATA COLLECTION SHEETS

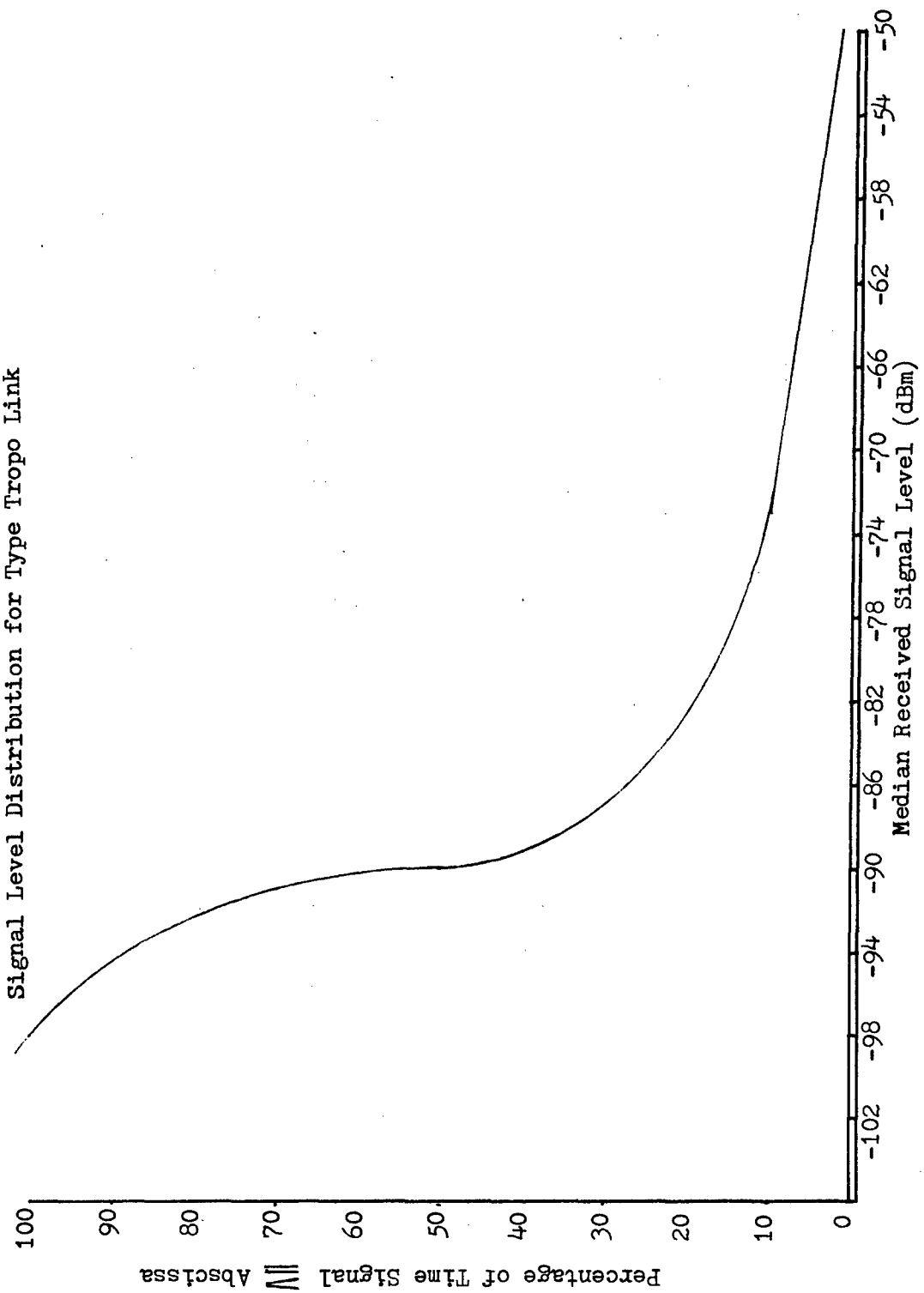
DATA COLLECTION SHEET #1

Median Incoming Signal Levels for a Type TropO Link



DATA COLLECTION SHEET #2

Signal Level Distribution for Type Tropo Link



DATA COLLECTION SHEET #3

AMBIENT NOISE AND RECEIVED RF SIGNAL LEVELS

Date_____ Observer_____

Test Path Designation_____ Test Officer_____

Test Site Designation_____ Test Supervisor_____

TIME	NOISE LEVEL	RF LEVEL*	TIME	NOISE LEVEL	RF LEVEL*
0030			1230		
0100			1300		
0130			1330		
0200			1400		
0230			1430		
0300			1500		
0330			1530		
0400			1600		
0430			1630		
0500			1700		
0530			1730		
0600			1800		
0630			1830		
0700			1900		
0730			1930		
0800			2000		
0830			2030		
0900			2100		
0930			2130		
1000			2200		
1030			2230		
1100			2300		
1130			2330		
1200			2400		

*Data extracted from Time Totalizer Recorder.